Risk Assessment for Stormwater Infiltration Impacts on Proposed Wellfield

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Introduction

- Confidential client interested in developing a new residential-use wellfield
- Concerned about impacts that infiltrating stormwater might have on groundwater quality
- Primary measure for “impact” was probability of exceeding MCLs for metals and coliform

Site Description

- River valley through developing suburb
- Two alluvial formations form the primary aquifer
  - Shallow aquifer
  - Modeled as unconfined
  - Unsaturated zone 35 – 45 ft thick
  - Saturated zone 180 - 220 ft thick
  - Field-scale lateral K_{eff}: LN(75, 38) ft/day

Site Description, cont'd

- Multiple land-use types:
  - Commercial
  - Residential
  - Park
  - Agricultural
- Many areas not sewered for storm runoff
- Proposed wells distributed among these areas

Objectives

- Approximately evaluate impacts to one proposed well near an imminent development
- Approximately evaluate impacts to mixed water from entire proposed wellfield
- Consider only “normal” stormwater runoff (i.e., no other contaminant sources / events)
- Constraints:
  - Use available information
  - Short time frame

Methodology

- Employed a “top-down” approach
  - Begin with relatively simple (yet reasonable) approach to approximately evaluate impacts
  - Develop in more detail where justified by sensitivity studies and cost-benefit
- Initially:
  - Abstracted hydrologic processes (e.g., monthly)
  - Relatively simple hydrogeologic representation
  - Abstracted contaminant transport model

Methodology, cont'd

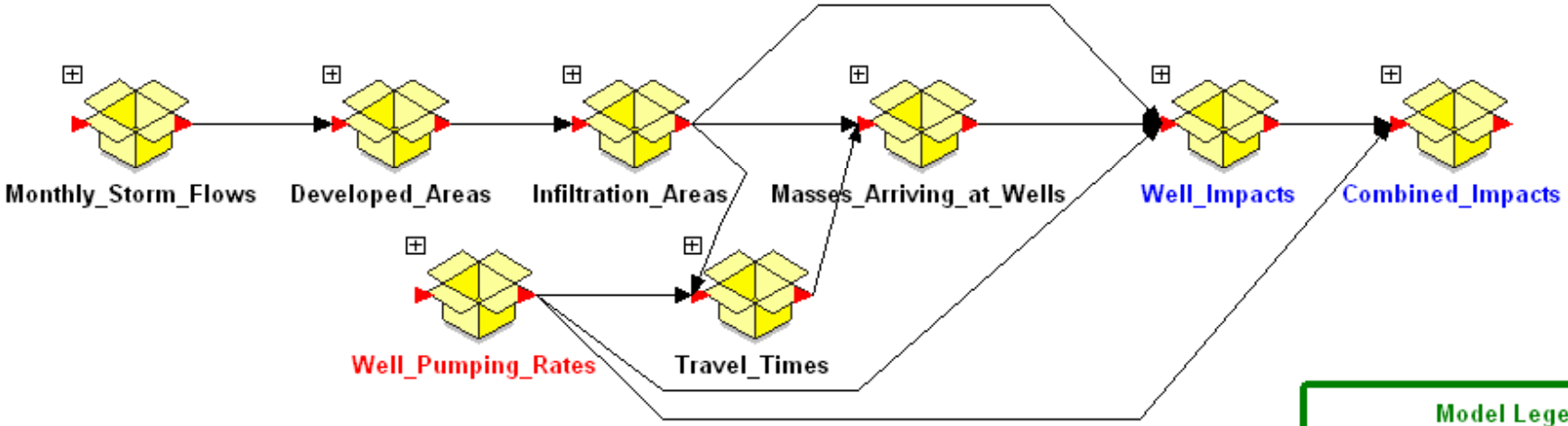
- Quantified significant uncertainties in (and correlations among) inputs, including:
  - Contaminant concentrations in storm runoff (by land-use type)
  - Average monthly storm flows (via monthly precip and monthly number of wet days)
  - Maximum infiltration flux
  - Travel times (via K, θ, n, sat and unsat zone thicknesses)
  - Mass-removal fractions (metals)
  - Decay constant (coliform)

Methodology, cont'd

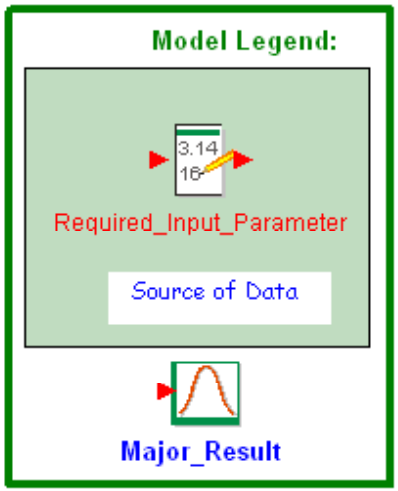
- Quantified uncertainty in water-quality impacts (i.e., output) via Monte Carlo
- Implemented approach within GoldSim®
  - Probabilistic, dynamic simulator
  - Object-oriented interface
  - Specialized functional elements
  - Substantial contaminant-transport capabilities

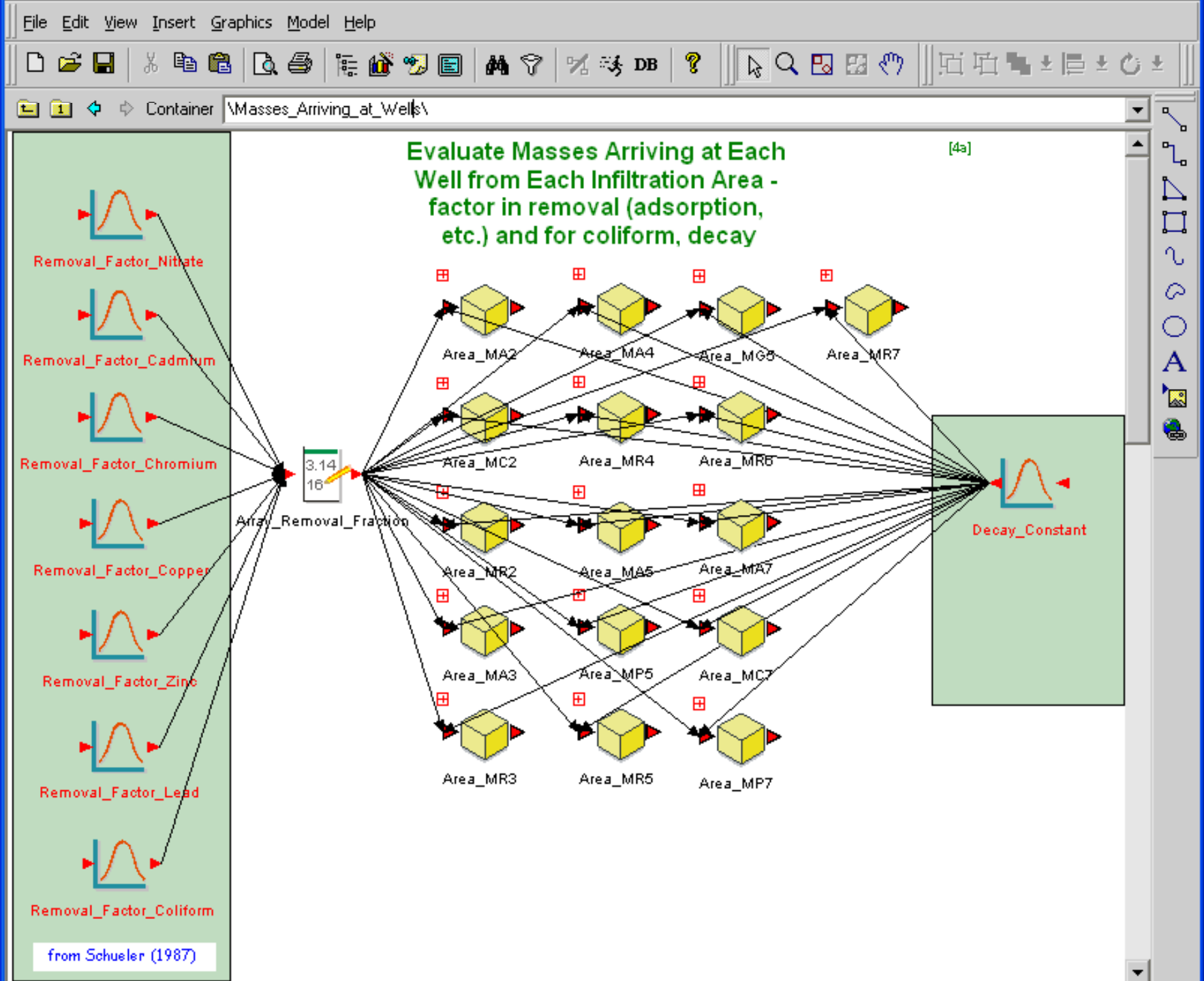
WELLFIELD RISK ASSESSMENT MODEL

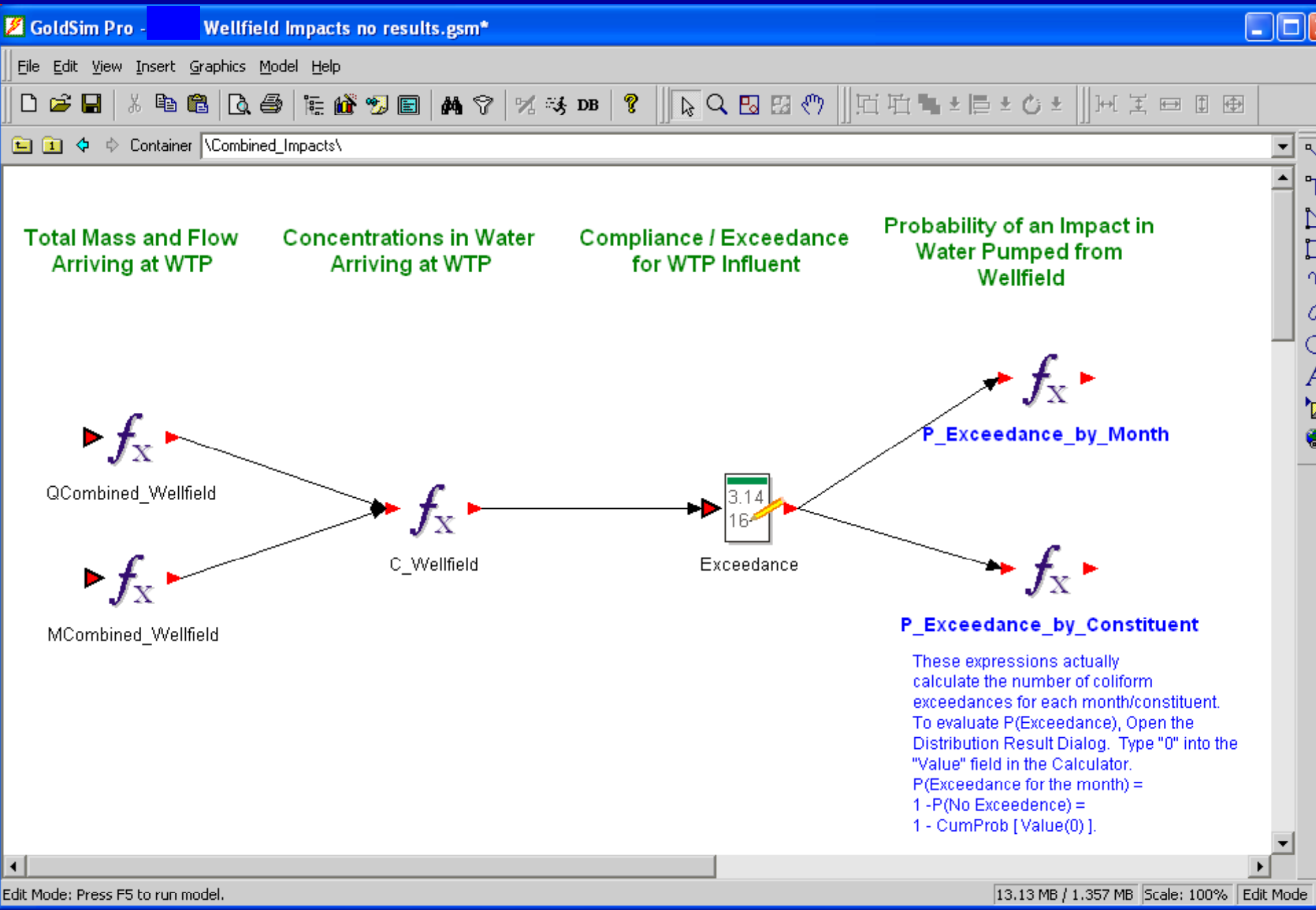
2,000 gpm, 10-yr capture zones for wells, uses distances between wells and closest points in infiltration areas



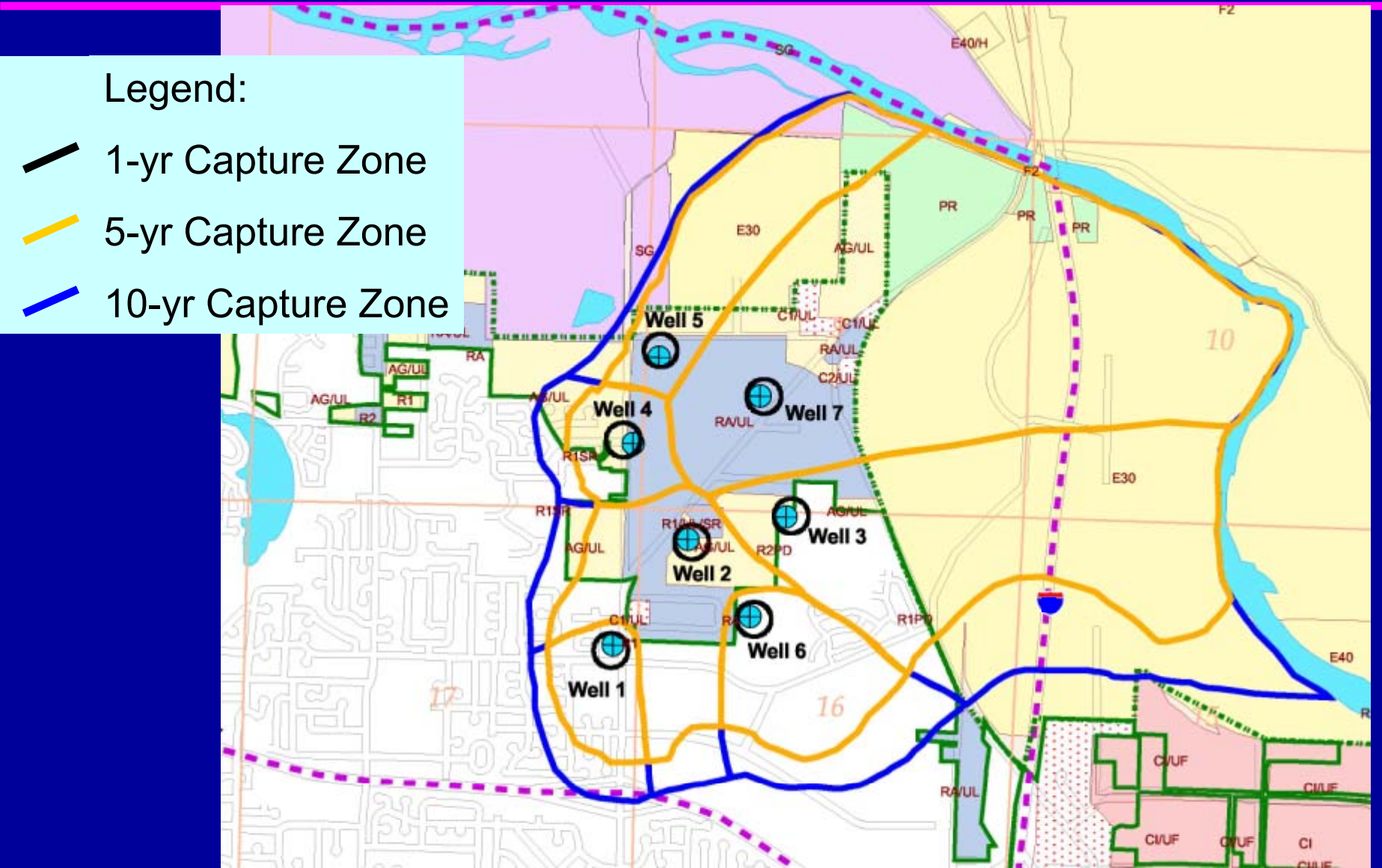
See report for equations and additional model documentation.
"Risk" here means P(Exceedance). Risk does not include consequences.



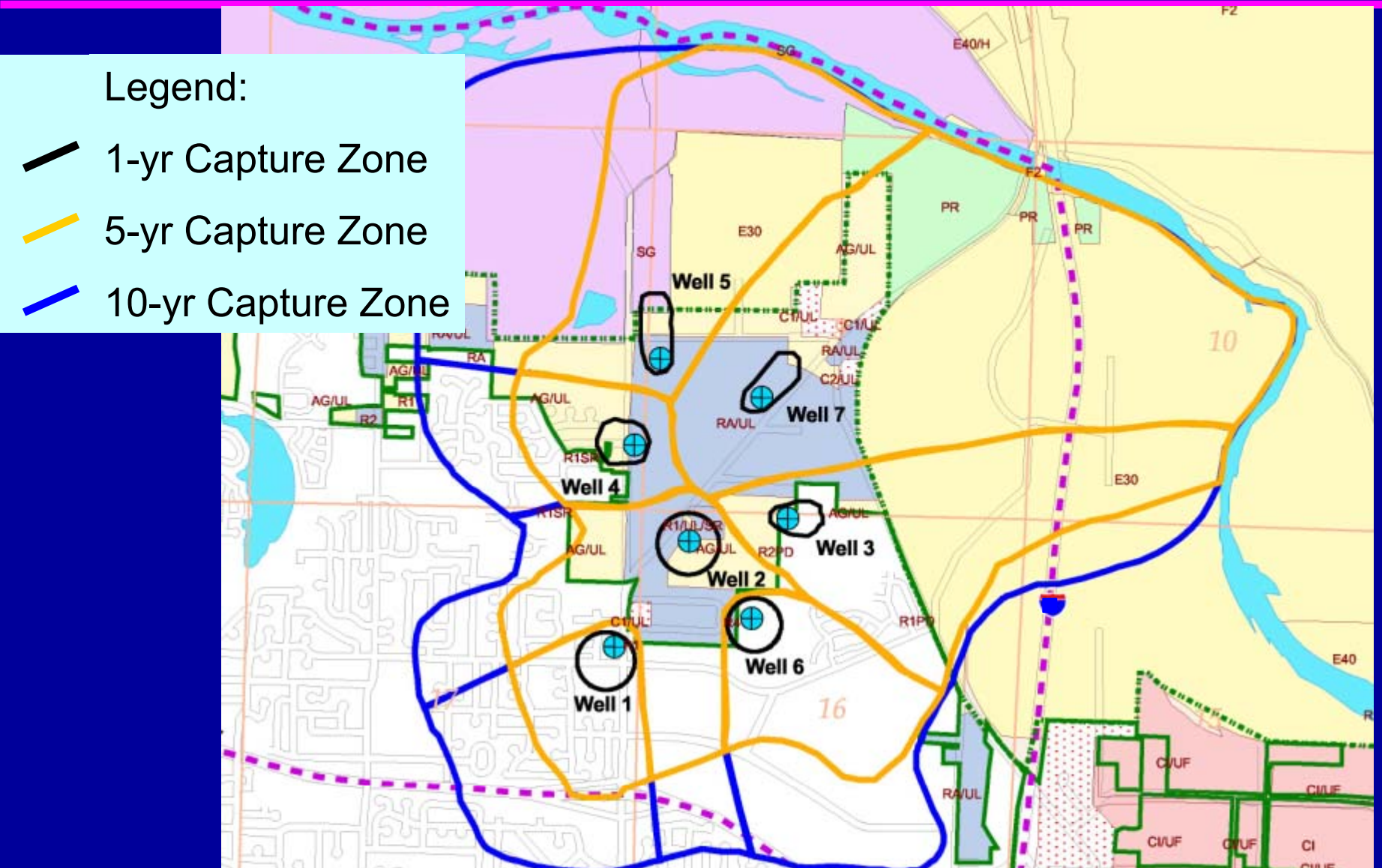

File Edit View Insert Graphics Model Help
Container \Masses_Arriving_at_Wells\
Evaluate Masses Arriving at Each Well from Each Infiltration Area - factor in removal (adsorption, etc.) and for coliform, decay
[4a]
Removal_Factor_Nitrate
Removal_Factor_Cadmium
Removal_Factor_Chromium
Removal_Factor_Copper
Removal_Factor_Zinc
Removal_Factor_Lead
Removal_Factor_Coliform
from Schueler (1987)
3.14
16
Array_Removal_Fraction
Area_MA2
Area_MA4
Area_MG5
Area_MR7
Area_MC2
Area_MR4
Area_MR6
Area_MR2
Area_MA5
Area_MA7
Area_MA3
Area_MP5
Area_MC7
Area_MR3
Area_MR5
Area_MP7
Decay_Constant


GoldSim Pro - Wellfield Impacts no results.gsm*
File Edit View Insert Graphics Model Help
Container \Combined_Impacts\
Total Mass and Flow Arriving at WTP
Concentrations in Water Arriving at WTP
Compliance / Exceedance for WTP Influent
Probability of an Impact in Water Pumped from Wellfield
QCombined_Wellfield
MCombined_Wellfield
C_Wellfield
3.14
16
Exceedance
P_Exceedance_by_Month
P_Exceedance_by_Constituent
These expressions actually calculate the number of coliform exceedances for each month/constituent. To evaluate P(Exceedance), Open the Distribution Result Dialog. Type "0" into the "Value" field in the Calculator.
P(Exceedance for the month) =
1 -P(No Exceedence) =
1 - CumProb [Value(0)].
Edit Mode: Press F5 to run model.
13.13 MB / 1.357 MB
Scale: 100%
Edit Mode

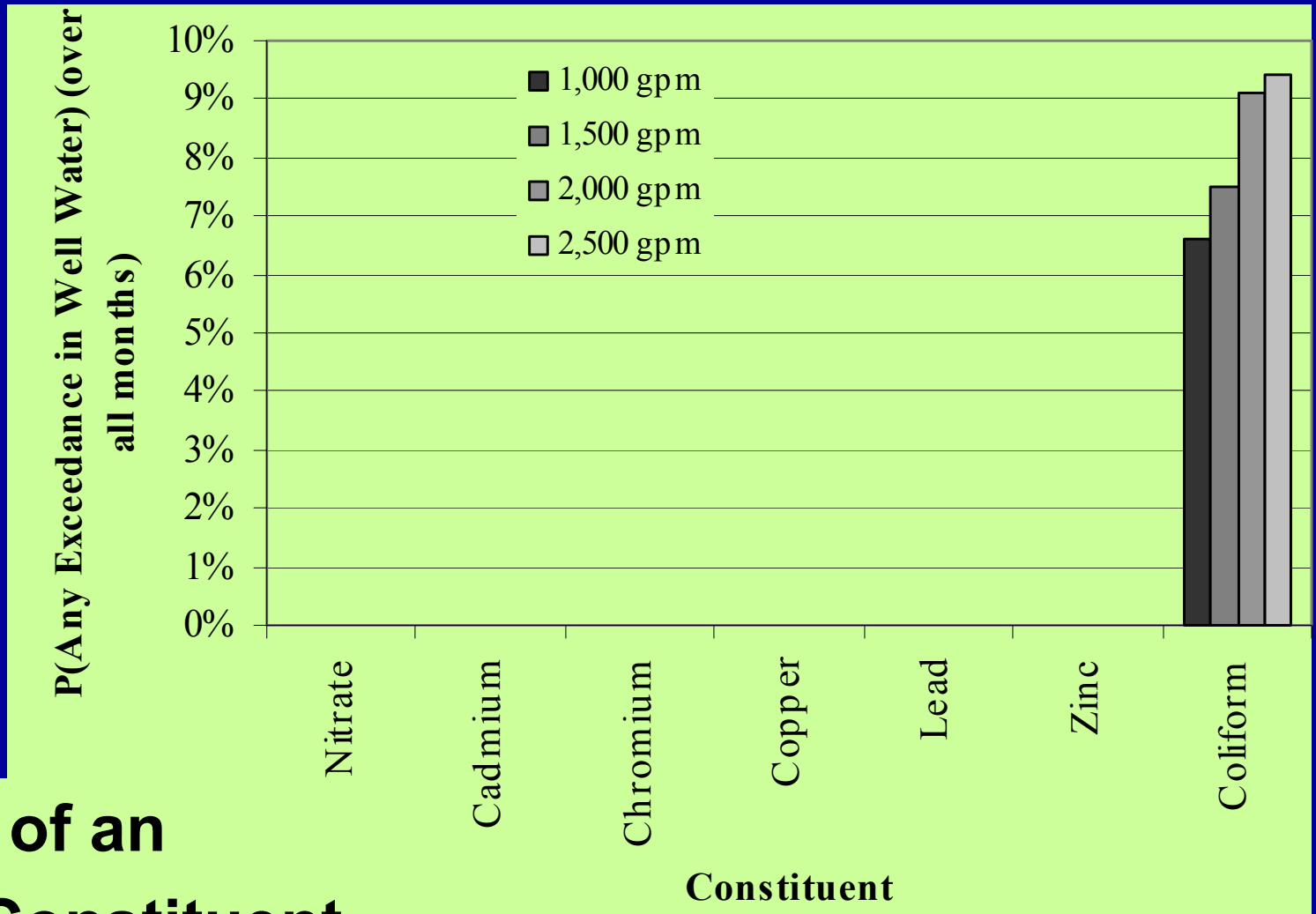
Contributory Area Sensitivity – 1,000 gpm



Contributory Area Sensitivity – 2,000 gpm

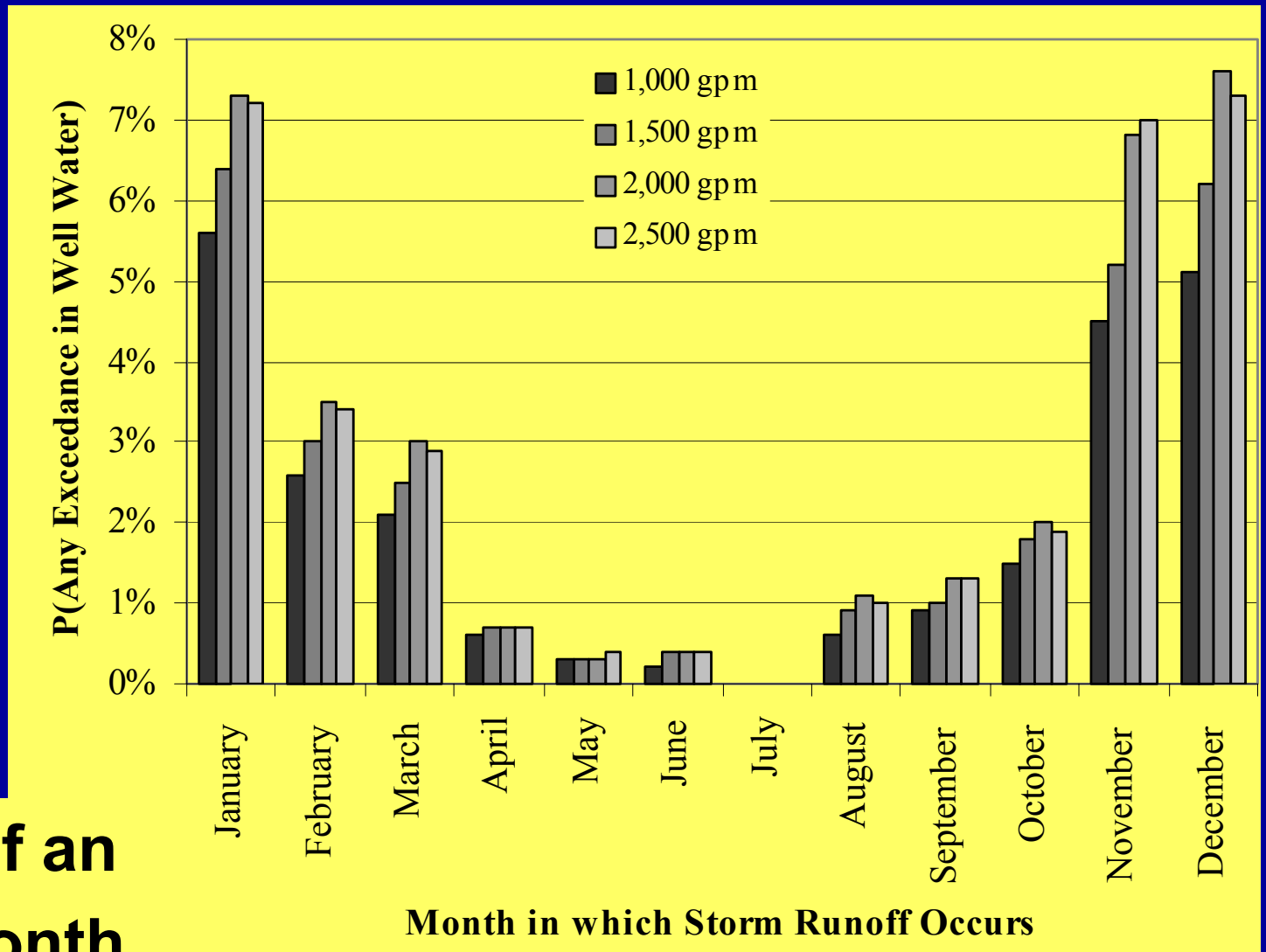


Results, cont'd – Water Pumped from Single Well



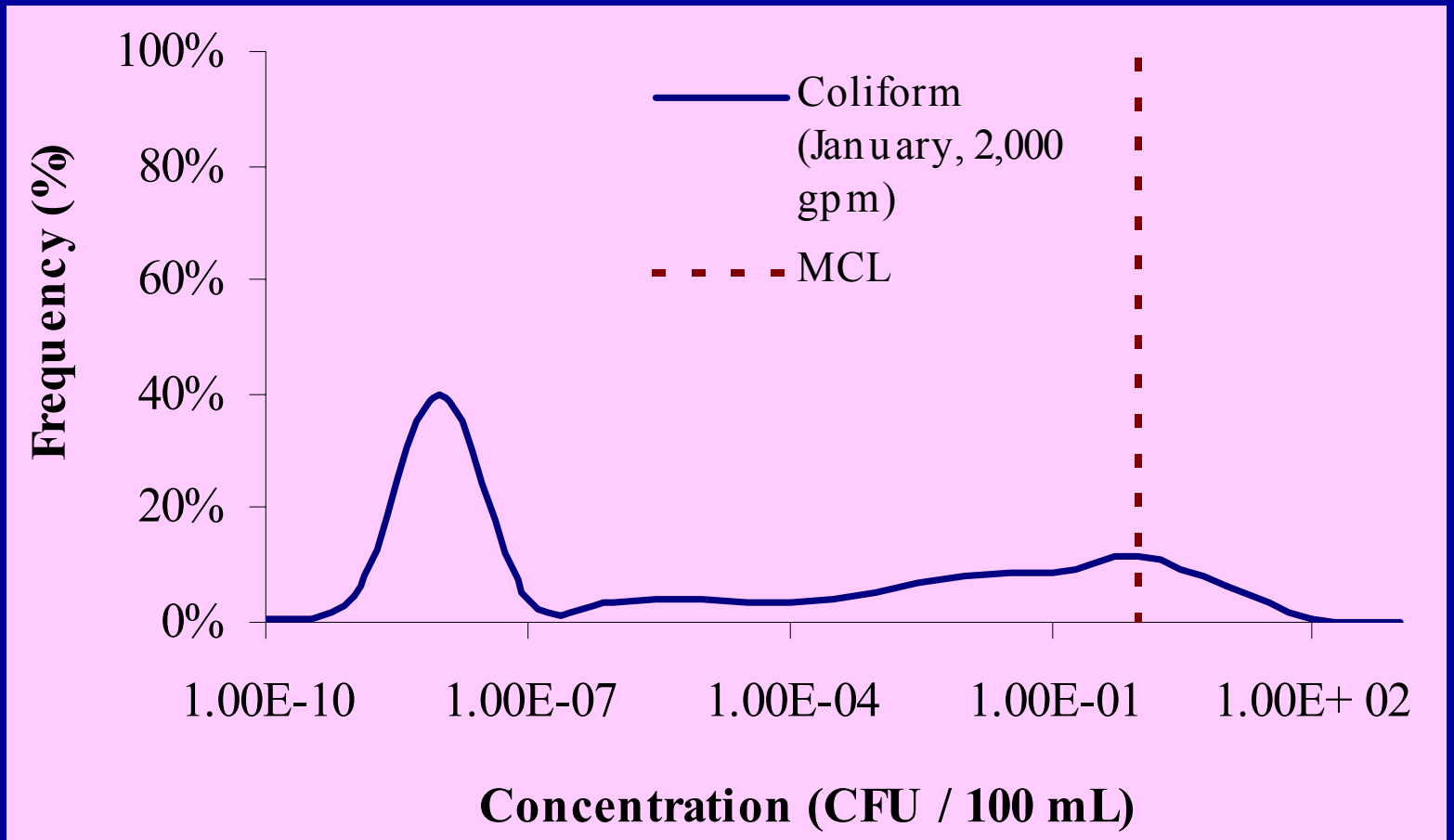
Probability of an Impact by Constituent

Results – Water Pumped from Single Well



Probability of an Impact by Month

Results, cont'd – Water Pumped from Single Well



Example Frequency Distribution - Coliform Concentrations

Results, cont'd – Entire Wellfield

- Assume water pumped from all wells is mixed together before compliance check
- Less than 0.1% chance of exceeding water-quality standards for:
  - Any constituent
  - Any month

Summary

- Simple, yet informative, probabilistic study
- Results from first level of “top-down” approach sufficient for initial client needs